MASTER COPY KEEP THIS COPY FOR REPRODUCTION PURPOSES

2

MENTATION PAGE

Form Approved
OMB No. 0704-0188

AD-A261 013

2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
Dec 91	Final 29 Oct 90-28 Oct 92

4. TITLE AND SUBTITLE
Sequential Acquisition Schemes for SSMA Systems with Generalized Signature Sequences

5. FUNDING NUMBERS
DAAL03-91-G-0001

6. AUTHOR(S)
Sawasd Tantaratana

DTIC ELECTE FEB 22 1993 S C D

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Massachusetts
Amherst, MA 01003

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U. S. Army Research Office
P. O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
ARO 27493.14-EL

11. SUPPLEMENTARY NOTES
The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The final report contains details of two important aspects of direct-sequence spread-spectrum (DS/SS) systems: acquisition of the signature sequence and error performance evaluation.

93-03275

14. SUBJECT TERMS
Tracting, Acquisition,
Direct-Sequence Spread-Spectrum Systems, Synchronization,
Signature Sequence

15. NUMBER OF PAGES
3

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

FINAL REPORT

1. ARO Proposal Number: 27493-EL
2. Title of Project: Sequential Acquisition Schemes for SSMA Systems with Generalized Signature Sequences
3. Grant Number: DAAL03-91-G-0001
4. Period: Oct. 29, 1990 – Oct. 28, 1992
5. Name of Institution: University of Massachusetts, Amherst
6. Author of Report: Sawasd Tantaratana
7. Summary of results:

This project investigates in detail two important aspects of direct-sequence spread-spectrum (DS/SS) systems: acquisition of the signature sequence and error performance evaluation.

Synchronization is probably the most difficult task a SS system receiver has to perform. This process aligns the phase of the locally generated signature sequence to the phase of the received signature sequence. It is normally achieved in two steps: acquisition, which is a coarse alignment of the phases, and tracking, which is a fine adjustment to bring the phase difference to zero. We have made several investigations to improve the acquisition process. The first improvement involves sequential acquisition schemes. Sequential schemes offer the most efficient (quickest to achieve acquisition) way to acquire a signature sequence. We proposed and developed design methods for some new sequential acquisition schemes, both with coherent demodulation and noncoherent demodulation [3][6][8][10]. These schemes are more efficient than previously reported schemes. The second improvement was on acquisition with the presence of data [7][11]. Most reported results on acquisition assume that there is no data during the acquisition period. However, there are many situations where it is necessary or desirable to perform acquisition while data is being transmitted. We showed that data modulation can seriously impair the performance of an acquisition system which was designed under the assumption of no data. We derived the optimum acquisition scheme with the presence of data and showed that a simple modification of the conventional method can essentially eliminate the effect of data modulation. This modification is an inclusion of simple correlator units. We also studied the effect of channel fading on acquisition systems [6][10]. It was found that Rician fading has an effect equivalent to reducing the SNR and that sequential acquisition schemes are somewhat more robust to the fading impairment than fixed-dwell schemes.

Another direction of this project was on the performances of DS/SS systems using complex signature sequences in a multiple-access (MA) environment [1][2][5][9][12][13]. Various modulation schemes, both coherent (Binary PSK, M-ary PSK, Sequence-shift keying (SSK)) and noncoherent (FSK, M-ary FSK, Differential PSK, and M-ary Differential PSK), have been investigated. Bounds and approximations for the probability of error were obtained. It was found that, in terms of the error probability, systems employing complex sequences can perform better than conventional systems which employ binary sequences. In addition, systems employing complex sequences can accommodate more users than systems employing binary sequences. This is because more sequences can be designed with good correlation properties when complex sequences are used. Such results suggest that complex sequences should be used in place of binary sequences in DS/SSMA systems, which is useful in applications such as mobile radio, where we would like to accommodate as many users as possible while retaining acceptable performance. Study also shows that complex sequences require approximately the same length of time to acquire as do binary sequences [4]. The tradeoff in using complex sequences is some increase in the complexity of the receiver.

8. Publications:

[1] A.W. Lam and F.M. Ozluturk, "Performance Bounds for Direct-Sequence Spread-Spectrum Communications with Complex Signature Sequences," *Proceedings of the 10th Annual IEEE International Phoenix Conference on Computers and Communications*, Phoenix, AZ, March 1991, pp. 408-414.

[2] A.W. Lam, F.M. Ozluturk, and S. Tantaratana, "M-ary DS/SSMA Communications with Complex Signature Sequences," *Proceedings of the 1991 Conference on Information Sciences and Systems*, Johns Hopkins Univ., March 1991, pp. 512-517.

[3] S. Tantaratana and A.W. Lam, "Noncoherent Sequential Acquisition for DS/SS Systems," presented at *the 29th Annual Allerton Conference on Communications, Control, and Computing*, Univ. of Illinois, IL, Oct. 1991, pp. 370-379.

[4] M. Salih and S. Tantaratana, "Acquisition of complex signature sequences for direct-sequence spread-spectrum systems," *Proceedings of the 1992 Annual Conference on Information Sciences and Systems*, Princeton University, NJ, March 1992, pp. 1090-1095.

[5] F.M. Ozluturk, S. Tantaratana, and A.W. Lam, "Probability of bit error for DS/SSMA systems with MPSK signaling and complex signature sequences," *MILCOM'92 Conference Record*, San Diego, CA, Oct. 1992, pp. 35.5.1-35.5.5.

[6] A.W. Lam, S. Tantaratana, and P.J. Vincent, "Effect of Ricean fading and data modulation on noncoherent PN sequence sequential acquisition schemes," *MILCOM'92 Conference Record*, San Diego, CA, Oct. 1992, pp. 17.1.1-17.1.5.

[7] J. Li and S. Tantaratana, "Acquisition schemes for PN sequences with data modulation," *MILCOM'92 Conference Record*, San Diego, CA, Oct. 1992, pp. 27.2.1-27.2.5.

[8] Y.H. Lee and S. Tantaratana, "Sequential acquisition of PN sequences for DS/SS communications: design and performance," *IEEE Journal on Selected Areas in Communications*, Vol. 10, pp.750-759, May 1992.

[9] A.W. Lam and F.M. Ozluturk, "Performance Bounds for DS/SSMA Communications with Complex Signature Sequences," *IEEE Trans. on Communications*, Vol. 40, pp. 1607-1614, Oct. 1992.

[10] S. Tantaratana, A.W. Lam, and P.J. Vincent, "Noncoherent Sequential Acquisition for DS/SS Communication with/without Channel Fading," submitted for publication, *IEEE Trans. on Communications*.

[11] J. Li and S. Tantaratana, "Optimum and Sub-optimum Acquisition Schemes for PN Sequences with Data Modulation," submitted for publication, *IEEE Trans. on Communications*.

[12] F.M. Ozluturk, S. Tantaratana, and A.W. Lam, "Performance of DS/SSMA Systems with MPSK Signaling and Complex Signature Sequences," submitted for publication, *IEEE Trans. on Communications*.

[13] F.M. Ozluturk, S. Tantaratana, and A.W. Lam, "Performance Bounds for DS/SSMA Systems with Noncoherent Signaling Schemes," submitted for presentation, *MILCOM'93*.

9. Theses (Dept. of Electrical and Computer Engineering, University of Massachusetts):

Jianlin Li, *Optimum and Suboptimum PN Acquisition Schemes with the Presence of Data Modulation.*, M.S. thesis, May 1992.

Fatih M. Ozluturk, *Performances of DS/SSMA Systems with Coherent and Noncoherent Signalings Using Complex Signature Sequences.*, Ph.D. Dissertation, May 1993 (in preparation).

10. Scientific personnel supported:

1. S. Tantaratana, Associate Professor
2. A.W. Lam, Assistant Professor
3. F.M. Ozluturk, research assistant
4. M. Salih, research assistant
5. J. Li, research assistant
6. I. Acar, research assistant
7. S. Ghanekar, research assistant

Degrees awarded:

Jianlin Li, M.S., Univ. of Massachusetts, May 1992.

Irfan Acar, M.S., Univ. of Massachusetts, May 1992.

Fatih M. Ozluturk, Ph.D., Univ. of Massachusetts, May 1993 (expected).